Test Equipment and Its Application for Measuring Milking Machine Operating Characteristics

STANDARD

Adopted and published by:

American Society of Agricultural Engineers

Technical and Editorial Change Notation:
The symbol T preceding or in the margin adjacent to section headings, paragraph numbers, figure captions, or table headings indicates a technical change was incorporated in that area when this document was last revised. The symbol T preceding the title of a document indicates essentially the entire document has been revised. The symbol E used similarly indicates editorial changes or corrections have been made with no intended change in the technical meaning of the document.

Test Equipment and Its Application for Measuring Milking Machine Operating Characteristics

Proposed by the Milking Machine Manufacturers Council of the Equipment Manufacturers Institute in conjunction with the ASAE IET 441 Milk Handling Equipment Committee; approved by the Electrical Power and Processing Division Standards Committee; adopted by ASAE March 1985; reconfirmed for one year December 1989; revised July 1996.

1 Purpose and scope

1.1 This Engineering Practice specifies mechanical tests for milking installations in order to verify compliance of an installation or component with the requirements of ASAE S518. It also stipulates the accuracy requirements for the measuring instruments.

1.2 This Engineering Practice is applicable for testing new installations and for periodic checking of installations for efficiency of operation.

1.3 This revision is based upon ISO/DIS 6690-1995, Milking Machine Installations—Mechanical Tests, and the US National Mastitis Council (NMC 1996) Procedures for Evaluating Vacuum Levels and Air Flow in Milking Systems.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreement based on this Standard are encouraged to apply the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

ASAE S300.3 JUL96, *Terminology for Milking Machines, Milk Cooling, and Bulk Milk Handling*

ASAE S518.2 JUL96, *Milking Machine Installations—Construction and Performance*

3 Definitions

For definitions, see ASAE S300.

4 Test equipment and specifications

Measuring equipment shall have a precision that ensures that requirements given in ASAE S518 can be recorded with the stated accuracy. The instruments shall be checked regularly to ensure compliance with the given specifications. They should be rugged and portable.

4.1 Measurement of vacuum level

Vacuum gauges shall have a range of 0 to 100 kPa (0 to 30 in. Hg). Test gauges used for on-farm measurements shall have an accuracy of +/- 1 kPa (0.3 in. Hg), and calibration-type gauges shall have an accuracy of +/- 0.5 kPa (0.15 in. Hg).

4.2 Measurement of vacuum changes

4.2.1 Vacuum recorders shall have a minimum operating range of 0 to 51 kPa (0 to 15 in. Hg) and shall withstand up to 68 kPa (20 in. Hg) without damage to the recorder. Recorders shall be able to indicate vacuum levels with an accuracy of +/- 1.5 kPa (0.45 in. Hg), and vacuum changes with an accuracy of +/- 0.5 kPa (0.15 in. Hg).

4.2.2 The vacuum recording system (that is, an analog or digital vacuum recorder with its connecting tubes and fittings) should have a response rate of at least 500 kPa/s (150 in. Hg/s).

NOTE – Response rate can be calculated easily by connecting the recording system directly to a pulsator (see figure 1) and recording the "a-phase" of the cyclic vacuum change (see figure 3 of ASAE S300). If the system vacuum level was 45 kPa, for example, then the a-phase is calculated as the time taken to respond to an abrupt change in input vacuum from 4 kPa to 41 kPa. If the a-phase was 50 ms, then the response rate of the recording system would be:

$$(45 - 4 - 4) \times 1000/50 = 740 \text{ kPa/s}$$

4.2.3 The vacuum recorder shall have a sampling rate of at least 16 Hz. A sampling rate of at least 64 Hz is preferred.

NOTE – At 16 Hz, the preferred response rate of the vacuum recording system should be at least 1000 kPa/s (300 in. Hg/s). This implies the use of a T-piece, rather than a 12- or 14-gauge hypodermic needle, for connection to the milking machine.

4.3 Measurement of pulsation characteristics

4.3.1 The instrument should have an operating range of 40 to 80 pulsation cycles/min and a minimum operating vacuum range of 0 to 51 kPa (0 to 15 in. Hg). Equipment shall withstand up to 68 kPa (20 in. Hg) without damage to the recorder.

4.3.2 The instrument used, including connecting tubes, shall have an accuracy of +/- 1 cycle/min for measuring pulsation rate and an accuracy of +/- 2% for measuring the pulsation phases and the pulsator ratio.

4.4 Measurement of air flow

4.4.1 The instrument used shall be capable of measuring with a maximum error of 5% of the measured value over a vacuum range of 30 to 60 kPa (8.9 to 17.8 in. Hg).

4.4.2 A fixed-orifice flowmeter is suitable for measuring air flows admitted from atmosphere such as effective reserve, manual reserve, system leakage, and vacuum pump capacities. A variable-area flowmeter, inserted

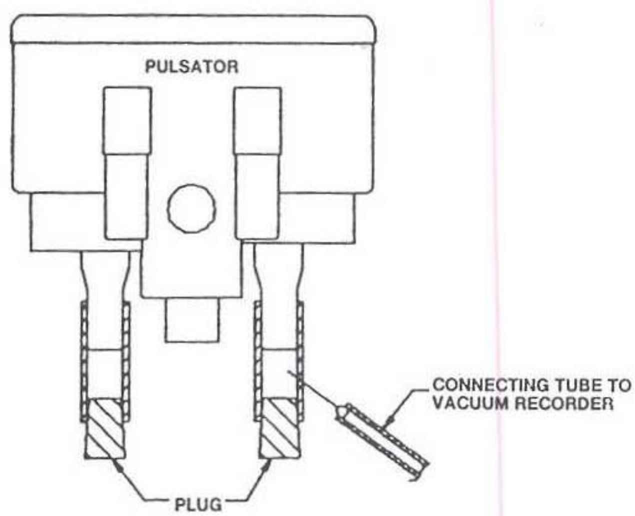

Figure 1 – Connection for measuring the response rate of vacuum recording systems

in the milk hose, is suitable for measuring air admission and air leakage into individual clusters.

NOTE – Air flowmeter readings should be corrected for vacuum level and the ambient atmospheric pressure according to instructions from the manufacturer. See additional guidelines in annex C2.

4.5 Measurement of pump speed

The instrument used shall be suitable for measuring the frequency of rotation (min^{-1}) with an accuracy of +/- 3% of the measured value.

4.6 Measurement of atmospheric pressure

The instrument used shall be capable of measuring the atmospheric pressure with an accuracy of at least +/- 1 kPa (0.3 in. Hg).

4.7 Teatcup plugs

Standard teatcup plugs, as shown in figure 4 of ASAE S300, should be used. The plugs shall withstand cleaning and disinfection and shall be suitable for use in contact with milk.

4.8 Instruction manuals

Manuals should be provided with the measuring equipment and contain complete specifications as well as specific information on the proper use, calibration, care, cleaning, and storage of the equipment.

5 Milking system test preparation

5.1 A visual check should be made to determine that the equipment is in good running order and that all controls are set per manufacturer's recommendations. Safety checks should be performed (see ASAE S518, 4.5).

5.2 Start the vacuum pump and put the milking machine into the milking position with all milking units connected. The milking system shall be run for a minimum of 10 min or until operating characteristics stabilize before taking measurements.

5.3 Teatcup plugs shall be fitted and all controls (e.g., automatic cluster remover systems) shall be in the milking position. All vacuum-operated equipment associated with the installation shall be connected including that not operating during milking.

5.4 Record atmospheric pressure.

5.5 Guidelines are given in annexes B and C for connection of test meters.

6 System vacuum levels and differences

6.1 Accuracy of farm vacuum gauge (see ASAE S518, 8.1)

6.1.1 With the milking machine operating as in 5.3, connect the test gauge to a test port close to the permanently mounted vacuum gauge and measure the vacuum level.

6.1.2 Calculate and record the *gauge error* as the difference between the vacuum level recorded in 6.1.1 and the reading from the permanently mounted gauge.

6.2 Vacuum drop in airlines (see ASAE S518, 9.1)

6.2.1 With the milking machine operating as in 5.3, connect the test gauge to a test port close to the vacuum pump inlet and measure the pump working vacuum level (figure 2).

6.2.2 Measure working vacuum at the regulator (or its sensor), in the pulsator airline furthest from the vacuum source, and at or near the receiver. In weigh jar systems, measure the working vacuum in the vacuum supply hose to the first weigh jar (figure 3).

6.2.3 Calculate and record the *vacuum drop* as the differences between the vacuum level measured in 6.2.1 and all vacuum levels measured in 6.2.2.

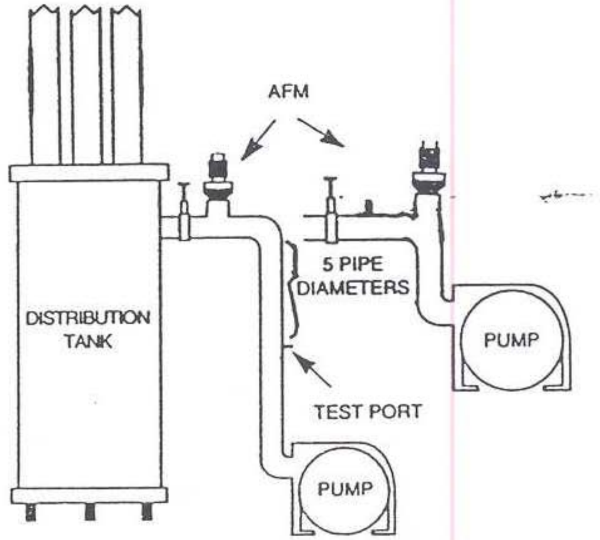

Figure 2 – Pump inlet vacuum

6.3 Cluster fall-off test (see ASAE S518, 7.3.1)

6.3.1 With the milking machine operating as in 5.3, connect the test gauge at or near the receiver (or vacuum supply hose to the first weigh jar in weigh jar systems) and measure the working vacuum.

6.3.2 Open one milking unit and hang it upside down to simulate a unit fall and record the vacuum reading on the test gauge. For systems with more than 32 units, open two units and repeat this measurement.

NOTES

1 To minimize measurement errors due to high air speeds, avoid opening a milking unit on the same milkline slope where working vacuum is measured.

2 For systems with two receivers and 32 units or less, this measurement should be carried out by opening one milking unit for one receiver. Record the result. Close the first unit, then open one unit on the other receiver and record the result. For systems with more than 32 units per receiver, open two units on one receiver and record the result. Close the first two units, then open two units on the other receiver and record the result.

6.3.3 Calculate and record the *vacuum differences* between the vacuum level at the receiver (or vacuum supply hose to the first weigh jar in weigh jar systems) measured in 6.3.1 and all vacuum levels measured in 6.3.2.

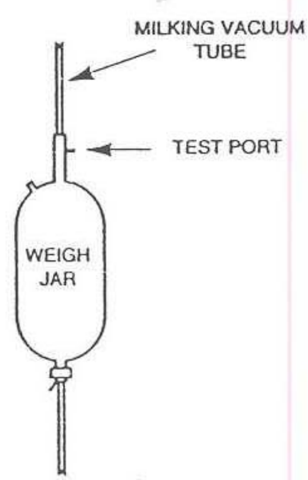

Figure 3 – Measurement of vacuum drop in weigh jar systems

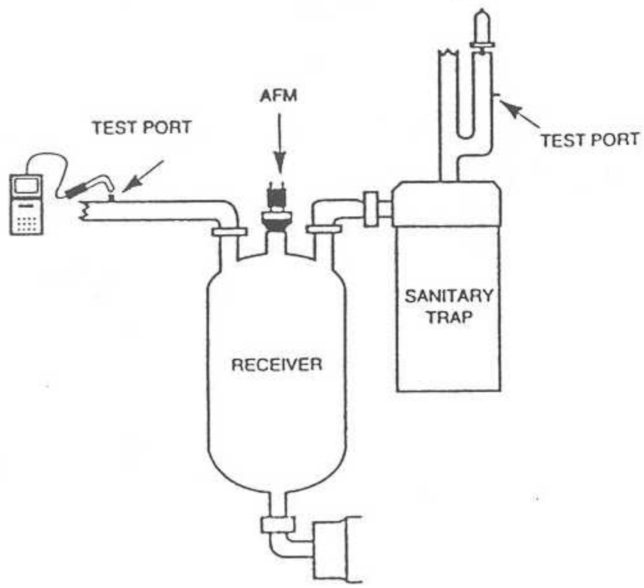

Figure 4 – Connection of air flowmeter

7 Air flow tests at receiver (or at sanitary trap in weigh jar milking machines)

7.1 Effective reserve (see ASAE S518, 6.2)

7.1.1 With the milking machine operating as in 5.3, connect an air flowmeter at or near the receiver on pipeline systems (figures 4 and 5) or to the vacuum supply line for weigh jar systems.

7.1.2 Open the air flowmeter until the working vacuum drops 2 kPa (0.6 in. Hg) at or near the receiver for pipeline systems. In recorder jar systems, measure this change in working vacuum in the vacuum supply hose to the first weigh jar, preferably on the opposite side of the parlor from the air flowmeter connection point.

7.1.3 Record the air flowmeter reading as the *effective reserve*.

7.2 Regulation loss and regulation efficiency (see ASAE S518, 7.3.2)

7.2.1 Determine effective reserve as detailed in 7.1.

7.2.2 Disable the regulator.

NOTE – Most servo-regulators can be put out of operation by disconnecting the vacuum sensing tube and taping or plugging the vacuum connection to the airline. Regulators designed to use air for "lubrication" can be put out of operation by removing the filter on top of the dome and taping the small air vent closed underneath this filter. When any of these types of regulators are disabled in this way, the resulting measurement gives the true manual reserve.

7.2.3 Readjust the air flowmeter until the working vacuum drops 2 kPa (0.6 in. Hg) at or near the receiver for pipeline systems (or vacuum supply hose to the first weigh jar in weigh jar systems).

7.2.4 Record the air flowmeter reading as the *manual reserve*.

7.2.5 Calculate and record the *regulation loss* as the difference between the manual reserve and the effective reserve measured in 7.1.

7.2.6 Calculate and record the *regulation efficiency* as the effective reserve (ER) expressed as a percentage of the manual reserve (MR):

$100 \times ER/MR$ percent.

7.3 Regulator leakage (see ASAE S518, 7.1.2)

7.3.1 With the milking machine operating as in 5.3, connect an air flowmeter at or near the receiver on pipeline systems (figures 4 and 5) or to the vacuum supply line for weigh jar systems, or near the regulator if there is a convenient connection point for the test.

7.3.2 Connect the test vacuum gauge to a test port at or near the regulator sensing point and record the vacuum level as the *regulator working vacuum* (or regulator set-point).

7.3.3 Open the air flowmeter until the regulator working vacuum drops 2 kPa (0.6 in. Hg).

7.3.4 Record the air flowmeter reading.

7.3.5 Disconnect the regulator and plug the connection.

7.3.6 Readjust the air flowmeter until the regulator working vacuum drops 2 kPa (0.6 in. Hg) below the level measured in 7.3.2 and record the air flowmeter reading.

7.3.7 Calculate and record the *regulator leakage* as the difference between the air flows recorded in 7.3.6 and 7.3.4.

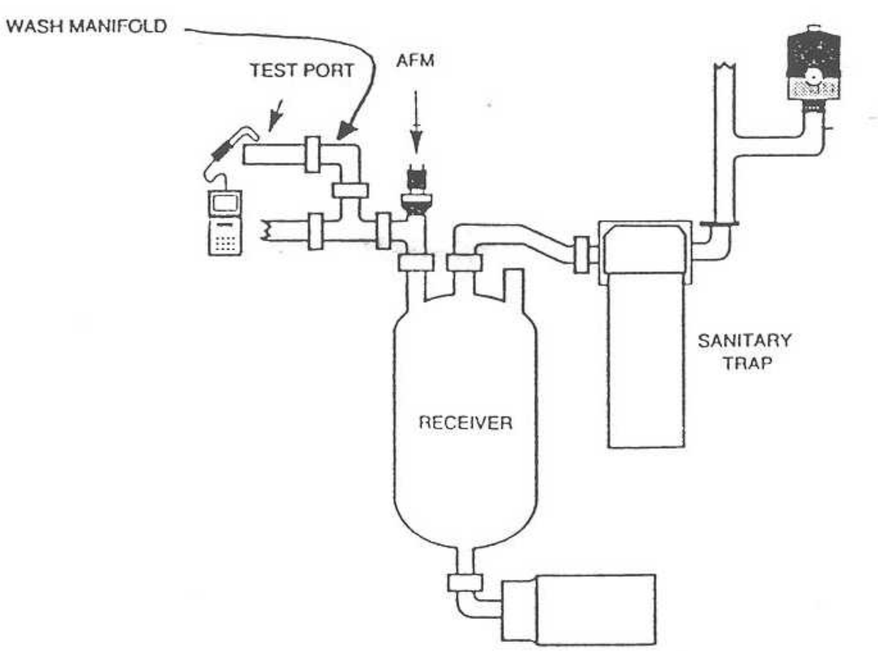

Figure 5 – Connection of air flowmeter

8 Air flow tests at or near vacuum pump

8.1 Air leakage into milkline and fittings (see ASAE S518, 15.1)

8.1.1 Turn off the vacuum pump(s). Disconnect the vacuum regulator and plug the connection. Stop or isolate the pulsators, the milking units, and all vacuum-operated equipment.

8.1.2 Connect an air flowmeter to a suitable T-piece near the vacuum pump as shown in figure 1 (or into the regulator connection point if there is no T-piece near the vacuum pump). Connect the test vacuum gauge to the test port near the pump inlet. Open the air flowmeter, and start the vacuum pump.

8.1.3 Adjust the air flowmeter until the vacuum level matches the measurement in 6.2.1, and record the air flowmeter reading.

8.1.4 Isolate the milk system by plugging the receiver airline (or trap line).

8.1.5 Readjust the air flowmeter until the vacuum level matches the measurement in 8.1.3, and record the air flowmeter reading.

8.1.6 Calculate and record *air leakage into the milk system* as the difference between the air flows measured in 8.1.5 and 8.1.3.

8.2 Vacuum pump capacity (see ASAE S518, 6.1)

8.2.1 Turn off the vacuum pump(s). Attach an air flowmeter as shown in figure 1, and connect the test vacuum gauge at or near the vacuum pump inlet. Isolate the vacuum pump and air flowmeter from the rest of the milking system.

8.2.2 Open the air flowmeter, and restart the vacuum pump(s).

8.2.3 Adjust the air flowmeter until the pump working vacuum matches the measurement made in 6.2.1.

8.2.4 Record the air flowmeter reading as the *vacuum pump capacity.*

8.3 Vacuum pump speed (see ASAE S518, 6.6)

With the milking machine operating according to 5.3 (or 8.2.3), measure and record the *vacuum pump speed* as its frequency of rotation (min^{-1}).

9 Air flow tests for individual milking units

9.1 Air leakage through vacuum shut-off valve (see ASAE S518, 19.2)

9.1.1 Connect a variable area air flowmeter between the long milk tube of an individual cluster and the milkline or weigh jar. The vacuum shall be set at the level recorded in 6.3.1 and the shut-off valve closed.

9.1.2 Correct the flowmeter reading for vacuum level (see 4.4.2), and record the corrected air flow as the *shut-off valve leakage* for the individual cluster.

10 Pulsation tests (see ASAE S518, clause 13)

10.1 Disconnect the short pulse tube from the pulsation chamber nipple on one teatcup (for systems with simultaneous pulsation) or two teatcups per milking unit (for systems with alternating pulsation). Drain any liquid from the pulsation chambers, and attach a suitable T-piece between the nipple and short pulse tube. Connect the T-piece to a vacuum recorder.

10.2 Record at least five pulsation cycles, and repeat the measurement for each unit.

10.3 Analyze according to the definitions given in ASAE S300 to obtain the pulsation rate, pulsator ratio, and the b- and d-phases for each unit.

11 Tests of vacuum stability during milking

Tests shall be conducted during a normal milking while the system is under full milk and air flow conditions.

11.1 Receiver vacuum stability (see ASAE S518, 6.2)

11.1.1 Connect a suitable vacuum recorder as near as practicable to the receiver, making sure that the connection is not in the milk stream. If necessary, the connection could be made in or through the sanitary trap.

11.1.2 Record the vacuum changes in or near the receiver for 2 to 3 cycles (turns) in a parlor, or for 15 to 20 min in a stanchion barn, while milking units are being attached, while the units are on the cows, and as units are detached.

11.1.3 Examine the recordings for any transient vacuum drop greater than 2 kPa (0.6 in. Hg).

11.2 Milkline vacuum stability (see ASAE S518, 14.1)

11.2.1 In stanchion barns, connect the vacuum recorder to a convenient, spare milk valve near the receiver end of the milkline, but at least 3 m (10 ft) from the receiver.

11.2.2 In parlors, slide the milk hose back 12 to 24 mm (0.5 to 1 in.) from a convenient milkline inlet at least 3 m (10 ft) from the receiver, and insert a 12- or 14-gauge hypodermic needle through the milk hose and milk inlet. The needle should be at least 64 mm (2.5 in.) long to ensure proper location of the needle in the milkline. Ensure that the open beveled end of the needle is positioned within the top of the milkline, facing toward the receiver and, as much as possible, out of the milk stream from the milking unit to which it is attached. When these readings are completed, remove the needle and push the milk hose over the milk nipple so that the puncture hole made by the needle is covered by the inlet nipple.

11.2.3 Record the vacuum changes in the milkline for 2 to 3 cycles (turns) in a parlor, or for 15 to 20 min in a stanchion barn, while milking units are being attached, while the units are on the cows, and as units are detached.

11.2.4 Examine the recordings for any transient vacuum drop more than 2 kPa (0.6 in. Hg) below the corresponding vacuum level measured in the receiver in 11.1.3.

12 Evaluation of results

12.1 The measurements should be compared with those published by the manufacturer in their manuals and those specified in ASAE S518 to evaluate the milking machine's performance.

12.2 The operating characteristics for milking machines vary as a result of different manufacturers' designs. Therefore these characteristics shall be taken into consideration when the results are evaluated.

12.3 Records of tests performed should indicate values for each measurement and the instrument used for each test performed.

NOTE – The report form developed and published in 1996 by the National Mastitis Council is suitable for recording the results of most of the tests described in this Engineering Practice.

Annex A
(informative)
Laboratory tests of vacuum drop in the milking unit

A1 Measuring equipment

A1.1 A *vacuum recording system* as specified in 4.2.1.

A1.2 An *artificial udder* with teats according to figure A1 made of rigid material with a flexible tube at the teat end in a material that will collapse by the pressure of a closed liner.

A1.3 A *water flowmeter* with a minimum accuracy as specified in annex A4, and an air flowmeter with a minimum accuracy as specified in annex A5.

A2 Measuring method

Mean vacuum level shall be recorded at the teat-end (via the transducer shown in figure A1), or in the claw bowl or at the claw outlet, while water is drawn through artificial teats (figure A1). The milking unit shall work normally. Pulsation data shall be recorded and specified.

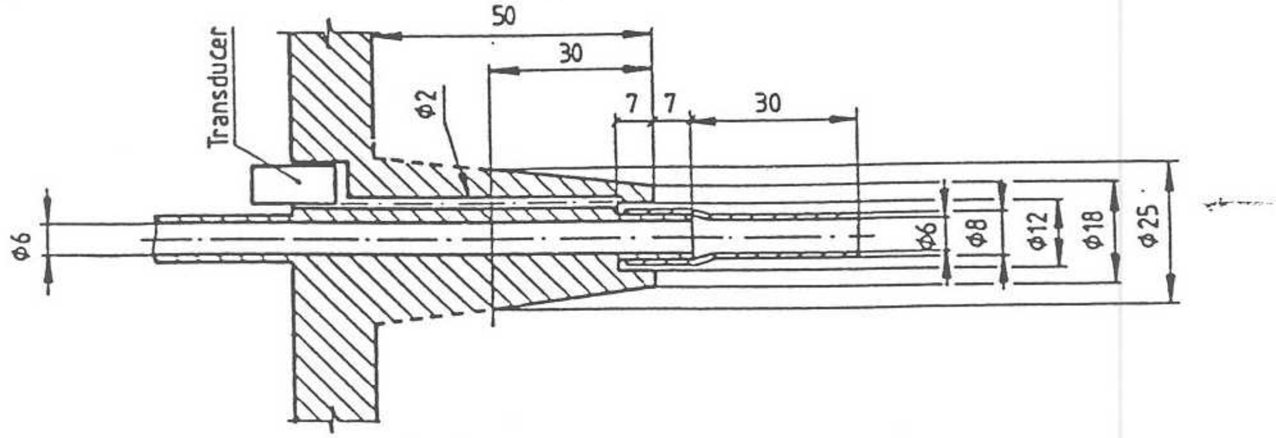

Figure A1 – Artificial teat. Dimensions are given in mm.

A3 Description of the connection to the plant

The connection to the plant shall be described by:

- length and internal diameter of the milk hose,
- the shape of the milk hose (see figure A2) by:
  - lifting height from the claw to the milkline (a),
  - lifting height from the teat base to the milkline (b),
  - vertical distance from claw to the highest point of the long milk tube (c),
  - vertical distance from the claw to the lowest point of the long milk tube (d),
  - horizontal distance from the claw to the milkline (e),
- description of the milk cock or milk inlet,
- description of the vacuum tap.

When units are being compared, the milk hose length shall be so matched that the distances b and e (see figure A2) will be the same for all units. So that measuring results can be compared, the dimension b should preferably be 1300 mm (52 in.) for highline, and 700 mm (28 in.) for lowline systems.

A4 Water flow rate

The water flow rate shall be specified and measured with an error of less than ± 0.25 L/min. The water temperature shall be 15 to 22 °C (59 to 72 °F). The reference water flow rate shall be 5.0 ± 0.25 L/min. If other flow rates are used they should be chosen from the following: 0.5, 1, 3, 6, 9, or 12 L/min.

A5 Air flow rate

The air flow through the air vent shall be measured. The designated air admission rate through the test cluster shall be 8.0 ± 0.5 L/min. If other flow rates are used they should be chosen from the following: 4, 12, 15, or 20 L/min.

A6 Measurement of the vacuum drop from components in the milk hose

The effect of components in the long milk tube shall be calculated by measuring the mean vacuum in a specified milking unit both with and without the component connected and by comparing the results.

A6.1 Install the milking unit without components in the milk hose and record the measurements specified in A3.

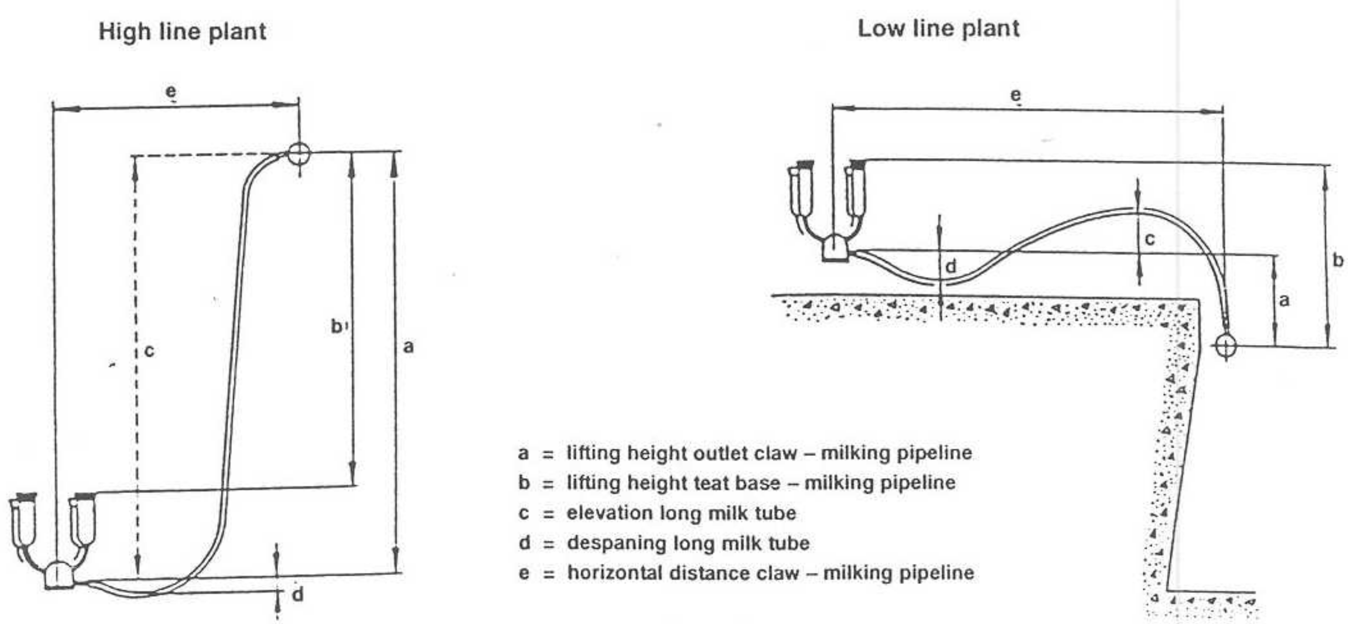

Figure A2 – Measurements for the installation of milking unit, with representative shape of the long milk tube

A6.2 Record the mean vacuum with a water flow rate of 5 L/min, split equally between all teatcups of a cluster.

A6.3 Install the test component in the milk hose as specified by the manufacturer. Tubes normally used with the tested component shall be used. Adjust the length of the milk hose so that the dimensions measured according to A6.1 are replicated for the test given in A6.4.

A6.4 Record the mean vacuum with the same water flow rate as in A6.2.

A6.5 The vacuum drop caused by the tested component is the difference in the mean vacuum levels recorded in A6.2 and A6.4.

Annex B
(informative)
Guidelines for accurate measurement of vacuum level

Do not trust the vacuum gauge on top of the air flowmeter unless the vacuum sensing tube has been lengthened to extend through the air flowmeter and into the receiver.

Suitable points for measurement of vacuum level in "quiet air" (air flow with minimal turbulence) on the sanitary side of the sanitary trap are as follows:

- top of receiver with special test lid that has a nipple to attach hose to the vacuum gauge.
- first milk inlet on the milkline in parlor.
- milk inlet/nipple on wash manifold in round-the-barn pipelines with the system set in wash mode.
- vacuum supply hose to first weigh jar.

Annex C
(informative)
Guidelines for accurate measurement of air flow

C1 Air flowmeter connections

For accurate air flowmeter readings, the flowmeter should be placed at or near the receiver (for direct-to-pipeline systems) or on the vacuum supply for weigh jar systems. Follow the air flowmeter manufacturer's recommendations when making measurements. It is important that the connection not restrict air port size to a size smaller than the throat of the flowmeter. In all cases, use the largest possible test port or flowmeter adapter size. Avoid restrictions. Following are some guidelines for minimum opening size:

Less than 2850 L/min (100 ft^3/min)	=	30 mm (1.2 in.) minimum opening
2850 to 5000 L/min (100 to 175 ft^3/min)	=	50 mm (2.0 in.) minimum opening
More than 5000 L/min (175 ft^3/min)	=	75 mm (3.0 in.) minimum opening

C2 Corrections to air flowmeter readings

Most air flowmeters are calibrated to be accurate within +/- 5% at 50 kPa (15 in. Hg). At lower vacuum levels, the mass flow rate of air through each metering hole is reduced. For example, the mass flowrate at 33 kPa (10 in. Hg) is about 10% lower than at 50 kPa (15in. Hg). Manufacturers can provide calibration charts for their flowmeters.

Generally, the correction factors are small and can be ignored for measurements made between 44 and 50 kPa (13 and 15 in. Hg). At lower vacuum levels, and/or at high air flow rates, it is good practice to make the necessary corrections. As a practical guideline, correction should be made to meter readings if the error is likely to exceed +/- 55 to 85 L/min (2 to 3 ft^3/min) at air flows up to about 1400 L/min (50 ft^3/min), or +/- 5% at higher air flows.